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INTEGRATED ELECTRICAL CONNECTOR

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[0001] The United States Government has rights in this invention pursuant to Contract No. W-7405-ENG-48 between the United States Department of Energy and the University of California for the operation of Lawrence Livermore National Laboratory.

Background of the Invention

[0002] The invention relates to an electrical connector and, more particularly, a conducting sheet integrated into an electrical chip and having an opening for making electrical contact with a contact pin inserted therethrough and for holding the pin within the opening.

[0003] Micro electrical apparatus are used where a very small size is required, such as in electronic chips and micro fluidic devices. However, their minute dimensions make it very difficult to electrically connect them to related circuitry, other components or power sources. Such connections are typically made using conductive epoxy or solder, both of which are very difficult to microscopically apply with precision. The inaccuracy and error inherent in applying epoxy and solder to microscopic areas can result in short circuits or unintended connections. Furthermore, the foregoing connections are rigid and fixed, making the repair or replacement of components time consuming and difficult.

[0004] One approach to this problem is to fabricate an electrical interface that is compatible with the two electrical elements being connected. However, the interface is typically larger than the micro device being connected, and thus compromises the advantage in size otherwise gained by using such a device.

[0005] As may be seen from the foregoing, there presently exists a need in the art for an electrical connector which is minute and provides for easy connection

and disconnection, while not being prone to causing a short circuit or other unintended electrical connection while being connected or disconnected. The present invention fulfills this need in the art.

Summary of the Invention

[0006] Briefly, the present invention is an electrical connector that is an integral part of an electrical chip and is electrically connected to one or more electrical elements embedded therein. The connector is formed from a sheet of electrically conductive material that lies in between and is held in place by nonconducting layers of material that form the casing of the chip. The connector provides an electrical connection between the chip and external circuitry, electrical components, or a power source; reliably maintains the connection; and allows the chip to be quickly disconnected when desired.

[0007] An opening in the sheet is concentrically aligned with a pair of larger holes respectively bored through the nonconducting layers composing the chip casing. The opening and holes are sized to accept a conductive contact pin to be inserted therethrough when the chip is to be electrically connected to the device or component that is electrically connected to or a part of the contact pin. The minimum breadth of the opening is smaller than the diameter of the contact pin and the sheet is composed flexible material so that the opening adapts to the diameter of the contact pin when the pin is inserted therethrough. Moreover, the periphery of the opening applies a normal force to the sides of the contact pin when the pin is inserted, and thus holds the pin within the opening by friction. This maintains the electrical connection.

[0008] Metal lines buried in the chip connect the connector to an electrical element embedded within the chip. The pin can be withdrawn from the connector by applying sufficient axial force. The chip can thus be easily

disconnected from the external components or elements electrically connected to the contact pin.

[0009] Where a chip contains a plurality of electrical elements, a connector for each of the elements is formed from the sheet. The connectors are electrically isolated from each other, and each is electrically connected, respectively, to an electrical element embedded in the chip. Each of the openings is respectively aligned with a pair of holes in the layers comprising the chip casing. The contact pins are attached together by a harness so that all of the pins can be simultaneously inserted, or disconnected, in one step. The harness is held in place by the friction applied by the connectors against the respective contact pins.

[0010] The electrical connector of the invention obviates the need for using epoxy, solder, or a bulky electrical interface to electrically connect a chip with other electrical components or circuitry, and provides for easy disconnection. As the chip is oftimes an integral part of a micro electromechanical or microfluidic system, the connector of the present invention allows standard hardware to be used to mechanically connect the system that includes the chip to other devices at the same time the electrical connection is being made. The present invention thus allows the use of standard connecting hardware originally designed for semiconductor integrated circuits such as dual inline sockets and pin grid arrays, as well as connecting hardware designed to make fluid or fiber optic connections with the chip.

[0011] These and other features, aspects and advantages of the present invention will become better understood with reference to the following drawings, description and claims.

Brief Description of the Drawings

[0012] Figure 1 is a top view of the electrical connector of the present invention embedded within an electrical chip.

[0013] Figure 2 is a side sectional view of the electrical connector of the present invention, taken along line 2 - 2 of Figure 1.

[0014] Figure 3 is the side sectional view of the electrical connector of the present invention shown in Figure 3, with a contact pin inserted therethrough.

[0015] Figure 4 is a top view of a chip including a plurality of the electrical connectors of the present invention. Part of the top layer is cut away to show the underlying connectors.

Detailed Description of the Invention

[0016] Turning to the drawings, Figure 1 shows a top view of connector 11 of the present invention located within chip 13. As shown in the side section view provided by Figure 2, chip 13 is comprised of top layer 15 and bottom layer 17. Both layers are composed of ceramic, nonconductive material. Sheet 18 is sandwiched in between top layer 15 and bottom layer 17, and is composed of flexible conductive material, such as beryllium copper. To give an idea of scale, chip 13 is 0.5 to 2.0 mm thick, and sheet 18 is 0.05 to 0.2 mm thick. Connector 11 is formed from sheet 18. Sheet 18, and thus connector 11, is electrically connected to an electrical element (not shown) embedded within chip 13 by means of wire 19.

[0017] Connector 11 includes centripetal fingers 20, 21, 23 and 25 that converge to form opening 27. Opening 27 is a polygon having a maximum breadth and a minimum breadth. Top layer 15 includes hole 29, and bottom layer 17 includes hole 31. Hole 29 has a diameter greater than the maximum breadth of opening 27, and hole 31 has a diameter greater than that of hole 29. Opening 27, hole 29, and hole 31 are concentric, and share axial centerline 33.

[0018] Alternatively, opening 27 may be a shape other than a polygon, e. g., a circle, an ellipse or a slit. If a circle, the diameter of opening 27 would be less than the diameter hole 29.

[0019] Cylindrical contact pin 35 is electrically conductive, and is connected to an electrical device (not shown) external to chip 13. Pin 35 has a diameter greater than the original, unstressed minimum breadth of opening 27, and less than that of hole 29. As illustrated in Figure 3, when pin 35 is inserted through opening 27, it stresses opening 27 by forcing the centrifugal bending of fingers 20, 21, 23 and 25, thereby increasing the minimum breadth of opening 27 until it equals the diameter of pin 35. This causes fingers 20, 21, 23 and 25 to contact and exert a normal force against the side of pin 35.

[0020] When an axial force is applied to pin 35 in a direction that would withdraw it from opening 27, the normal force generates a frictional force opposing such a withdrawal force. This frictional force tends to hold pin within opening 27 and restrain it from being withdrawn. At the same time, the contact between fingers 20, 21, 23 and 25, and pin 27 establishes an electrical connection between connector 11 and pin 27, and thus between the electrical element in chip 13 connected to connector 11 and the electrical device connected to pin 35.

[0021] As shown in the top view provided by Figure 4, chip 13 may contain a plurality of connectors 11, with each connector 11 being connected to an electrical

element embedded within chip 13. For example, one of connectors 11 is shown connected to element 37. This configuration allows the simultaneous connection of a number of elements within chip 13 to a plurality of pins 35, and hence to a plurality of electrical devices or components external to chip 13, respectively. More particularly, pins 35 are attached to a rigid harness (not shown). Pins 35 are spatially arranged so that each pin 35 will be simultaneously inserted into a respective opening 27 when the harness is positioned adjacent to or abutting chip 13. In addition to preventing the translation of pins 35 with respect to chip 13 and maintaining the electrical connection of pins 35 and the elements embedded within chip 13, this configuration prevents the rotation of pins 35 and the harness with respect to chip 13.

[0022] It is to be understood, of course, that the foregoing description relates to several embodiments of the invention and that modifications may be made without departing from the sprit and scope of the invention as set forth in the following claims.